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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/686,768	10/17/2003	Kyeong-mo Koo	SEC.1034CIP	7742
20987	7590	03/08/2005	EXAMINER	
VOLENTINE FRANCO, & WHITT PLLC ONE FREEDOM SQUARE 11951 FREEDOM DRIVE SUITE 1260 RESTON, VA 20190			LE, THAO P	
			ART UNIT	PAPER NUMBER
			2818	

DATE MAILED: 03/08/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/686,768	Applicant(s) KOO ET AL.	
	Examiner Thao P. Le	Art Unit 2818	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 March 2005.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-21,23-28,30-34 and 36-51 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-21,23-28,30-34 and 36-51 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. Examiner took notice of remarks and amendments made on 02/07/05 and 03/02/05, however, the amendments do not overcome the prior art and therefore a new rejection is being made.

EXAMINER'S AMENDMENT

2. Authorization for this examiner's amendment was given through a telephone interview with Attorney Linus Y. Park on 03/02/05. The application was amended as follow:

Amend claims 26, 30, 31 and cancel claim 29.

Claim 26. (currently amended) A method of manufacturing a semiconductor device, the method comprising:

forming an isolation region defining an active region on a semiconductor substrate;

forming, on the active region, a source/drain region and a gate, the gate having a sidewall spacer and being made of polysilicon doped with impurities;

pretreating the source/drain region and the gate to remove at least one of a natural oxide film and impurities formed thereon;

forming a cobalt-containing film on a surface of the substrate at a temperature between 300-500°C;

Art Unit: 2818

forming a titanium-rich capping film on the cobalt-containing film to obtain a resultant structure, the titanium-rich capping film having a titanium/other elements atomic⁵ ratio of more than 1; and

annealing the resultant structure so that cobalt of the cobalt-containing film and silicon of the gate and the source/drain region react with each other to form a cobalt silicide film.

Claim 30. (currently amended) The method according to claim ~~29~~ 26, wherein the pretreatment process comprises:

wet-cleaning the surface of the semiconductor substrate; and

etching the wet-cleaned surface of semiconductor substrate by radio frequency (RF) sputtering.

Claim 31. (currently amended) The method according to claim ~~29~~ 26, wherein the pretreatment process is devoid of radio frequency (RF) sputter etching.

3. Claims 1-21, 23-28, 30-34, 36-51 are pending in this application.

Claim Rejections

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

Art Unit: 2818

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 1-21, 23-28, 30-34, 36-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al., U.S. Patent No. 6,551,927, and further in view of Ku et al., U.S. Patent No. 6,329, 276.

Regarding claims 1, 13, 25, 26, 38, and 50, Chen discloses a method of forming a cobalt silicide film (See Figs. 1-4, Cols. 1-6), said method comprising:

- forming a cobalt-containing film 20 on a surface of a semiconductor substrate having an insulating region and a silicon-containing conductive region (Fig. 2);

- forming on a active region, a source/drain region and a gate, a sidewall spacer (Fig. 2) and being made of polysilicon doped with impurities (patent numbers cited as prior art in lines 34-57, Col. 1);

- forming a titanium-rich capping film 22 on the cobalt-containing film to obtain a resultant structure, the titanium-rich capping film having a titanium/other elements atomic % ratio of more than 1 (the term "titanium-rich" means that the amount

Art Unit: 2818

of titanium is more than other elements and the atomic percent ratio of titanium and other elements is greater than 1);

annealing the resultant structure so that cobalt of the cobalt-containing film and silicon of the silicon-containing conductive region react with each other to form the monocobalt monosilicide film 30 (CoSi, Fig. 4).

Still regarding claims 25, 50, Chen also discloses the step of removing the capping film and the cobalt-containing film remaining unreacted in the first rapid thermal annealing, and performing a second rapid thermal annealing at a second temperature which is higher than the first temperature so that the monocobalt monosilicide film is transformed into a monocobalt disilicide film CoSi₂ (lines 7-15, Col. 3).

Still regarding to claims 1, 13, 25, 26, 38, and 50, Chen fails to disclose the formation of cobalt-containing film is being formed at a temperature of about 300-500 oC at which cobalt of the cobalt-containing film and silicon of the silicon-containing conductive region react with each other to form a diffusion restraint interface film made of dicobalt monosilicide or monocobalt monosilicide. However, Ku et al discloses the formation of cobalt-containing film is being formed at a temperature of about 400-600 oC (within the temperature range as cited in present application) at which cobalt of the cobalt-containing film and silicon of the silicon-containing conductive region react with each other to form a diffusion restraint interface film made of cobalt monosilicide (lines 65-67, Col.3; lines 1-2, Col. 4). It would have been obvious to one having ordinary skill in the art that cobalt-containing film is formed at a temperature of about 300-500 oC

Art Unit: 2818

because the cobalt reacts with silicon at the above temperature to form a diffusion restraint interface film made of cobalt monosilicide.

Regarding claims 2-3, 14-15, 27-28, 39-40, Chen et al. discloses the capping layer is a titanium rich nitride (abstract). It is inherent that titanium rich nitride having a titanium/nitrogen atomic % ratio of more than 1.

Regarding to claims 11, 23, 36, 48, Chen also discloses the step of removing the capping film and the cobalt-containing film remaining unreacted in the first rapid thermal annealing, and performing a second rapid thermal annealing at a second temperature which is higher than the first temperature so that the monocobalt monosilicide film is transformed into a monocobalt disilicide film CoSi_2 (lines 7-15, Col. 3).

Regarding to claims 12, 24, 37, 49, Chen et al. discloses the first temperature and second temperature of the first and second annealing are in the range recited in claim 12 (lines 8-15, Col. 3).

Regarding claims 9, 21, 34, 46, Chen et al. discloses the cobalt-containing film 20 is a pure cobalt.

Regarding claims 4, 16, 29, 41, Chen et al. doesn't disclose the step of performing a pretreatment process on the silicon-containing conductive region before

Art Unit: 2818

forming cobalt-containing film. Ku et al. discloses the step of depositing a cobalt layer after performing a pretreatment process on the substrate. The substrate is wet cleaned with use of a chemical such as HF (lines 57-60, Col. 3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Chen et al. in view of Ku et al. by performing a pretreatment process on the substrate because the pretreatment process is performed on the substrate to remove a native oxide layer or impurities on the substrate to avoid unwanted reaction between cobalt and unwanted substances on the substrate.

Regarding claims 5-8, 17-20, 30-33, 42-45, Ku et al. discloses the pretreatment process is wet cleaning using HF solution but fails to disclose the pretreatment process comprises etching the wet-cleaned surface by radio frequency sputtering, devoid of radio frequency, wet-cleaning using HF diluted with DI water and ammonium hydroxide, hydrogen peroxide and water. It would have been obvious to one having ordinary skill in the art at the time the invention was made to choose those wet cleaning techniques using either one or both HF and water, or ammonium hydroxide, hydrogen peroxide and water and etching the wet-cleaned surface by radio frequency sputtering or devoid of radio frequency because the techniques and different solution used in wet cleaning would yield the same result, remove a native oxide layer or impurities on the substrate to avoid unwanted reaction between cobalt and unwanted substances on the substrate.

Regarding to claims 10, 22, 35, 47, 51, Chen fails to disclose the formation of cobalt-containing film is being formed at a temperature of about 300-500 °C at which cobalt of the cobalt-containing film and silicon of the silicon-containing conductive region

Art Unit: 2818

react with each other to form a diffusion restraint interface film made of dicobalt monosilicide or monocobalt monosilicide. However, Ku et al discloses the formation of cobalt-containing film is being formed at a temperature of about 400-600 oC (within the temperature range as cited in present application) at which cobalt of the cobalt-containing film and silicon of the silicon-containing conductive region react with each other to form a diffusion restraint interface film made of cobalt monosilicide (lines 65-67, Col.3; lines 1-2, Col. 4). It would have been obvious to one having ordinary skill in the art that cobalt-containing film is formed at a temperature of about 300-500 oC because the cobalt reacts with silicon at the above temperature to form a diffusion restraint interface film made of cobalt monosilicide.

6. When responding to the office action, Applicants' are advice to provide the examiner with the line numbers and page numbers in the application and/or references cited to assist the examiner to locate the appropriate paragraphs.

A shortened statutory period for response to this action is set to expire 3 (three) months and 0 (zero) day from the day of this letter. Failure to respond within the period for response will cause the application to become abandoned (see M.P.E.P 710.02(b)).

Conclusion

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thao P. Le whose telephone number is 571-272-1785. The examiner can normally be reached on M-T (7-6).

Art Unit: 2818

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Nelms can be reached on 571-272-1787. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Thao P. Le
Examiner
Art Unit 2818
November 11, 2004